A Hybrid Evolutionary Algorithm for Task Matching and Scheduling

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ABSTRACT

Heterogeneous cluster computing is regarded as a promising approach to solve CPU-intensive problems at a low cost. One can decompose a composite parallel program into constituent tasks so that these tasks can be assigned to different process elements (PEs) for concurrent execution. These tasks generally can be characterized by a task graph, which is represented as a directed acyclic graph (DAG). In this dissertation, we develop a hybrid evolutionary algorithm for allocating task graphs onto a heterogeneous cluster-computing system. Based on a general framework of genetic algorithms (GAs), this proposed algorithm is specific to its two operators: the topological order crossover (TOX) and the guided mutation (GM). We proof that the chromosomes generated by the TOX operator satisfy the precedence constraints and have higher validity as well while compared to the conventional single-point order crossover (OX). We also combine the GM operator and concepts of the simulated annealing (SA) so that a useless mutation can be avoided. The proposed algorithm is evaluated through a comparison with tabu search (TS), SA, and GAs in terms of the schedule length in DAGs. Experimental results show that the proposed algorithm outperforms the three while solving the task mapping and scheduling problem.

Keywords : task matching and scheduling ; genetic algorithms ; simulated annealing ; tabu search

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REFERENCES

[1]E. S. H. Hou, N. Ansari, and H. Ren, “ A Genetic Algorithm for Multiprocessor Scheduling, ” IEEE Trans. Parallel and Distributed Systems, Vol. 5, No. 2, pp. 113-120, February 1994.

[2]T. C. Hu, “ Parallel Sequencing and assembly Line Problems, ” Oper. Research, Vol. 19, No. 6, pp. 244-257, April 1989.

[3]R. Sethi, “ Scheduling Graphs on Two Processors, ” SIAM J. Computing, Vol. 5, No. 1, pp. 73-82, March 1976.

[4]W. H. Kohler and K. Steiglitz, “ Characterization and Theoretical Comparison of Branch-and-Bound Algorithms for Permutation Problems, ” J. ACM, Vol. 21, No. 1, pp 140-156, January 1974.

[5]T. L. Adam, K. Chandy, and J. Dickson, “ A Comparison of List Scheduling for Parallel Processing Systems, ” Comm. ACM, Vol. 17, No. 12, pp. 685-690, December 1974.

[6]T. Yang and A. Gerasoulis, “ List Scheduling with and without Communication Delays, ” Parallel Computing, Vol. 19, No. 12, pp. 1321-1344, December 1993.

[7]H. EI-Rewini and T. Lewis, “ Scheduling Parallel Programs onto Arbitrary Target Machines, ” J. Parallel and Distributed Computing, Vol. 9, No. 2, pp. 138-153, June 1990.

[8]B. Shirazi, M. Wang, and G. Pathak, “ Analysis and Evaluation of Heuristic Methods for Static Scheduling, ” J. Parallel and Distributed Computing, Vol. 10, No. 3, pp. 222-232, March 1990.

[9]M. Y. Wu and D. D. Gajski, “ Hypertool: A Programming Aid for Message-Passing Systems, ” IEEE Trans. Parallel and Distributed Systems, Vol. 1, No. 3, pp. 330-343, July 1990.

[10]J. Y. Colin and P. Chritienne, “ C.P.M. Scheduling with Small Communication Delays and Task Duplication, ” Oper. Research, Vol. 39, No. 4, pp. 680-684, July 1991.

[11]T. Yang and A. Gerasoulis, “ DSC: Scheduling Parallel Tasks on an Unbounded Number of Processors, ” IEEE Trans. Parallel and Distributed Systems, Vol. 5, No. 9, pp. 951-967, September 1994.

[12]M. AI-Mouhamed and A. AI-Mouhamed, “ Performance Evaluation of Scheduling Precedence-Constrained Computations on Message-Passing Systems, ” IEEE Trans. Parallel and Distributed Systems, Vol. 5, No. 12, pp. 1317-1322, December 1994.
[13]H. EI-Rewini, H. Ali, and T. Lewis, “ Task Scheduling in Multiprocessing Systems, ” Computer, Vol. 28, No. 12, pp. 27-37, December 1995.
[14]M. A. Palis, J. Liou, and D. S. L. Wei, “ Task Clustering and Scheduling for Distributed Memory Parallel Architectures, ” IEEE Trans. Parallel and Distributed Systems, Vol. 7, No. 1, pp. 46-55, January 1996.
[15]Y. K. Kwok and I. Ahmad, “ Dynamic Critical-Path Scheduling: An Effective Technique for Allocating Task Graphs to Multiprocessors, ” IEEE Trans. Parallel and Distributed Systems, Vol. 7, No. 5, pp. 506-521, May 1996.
[16]Yu-Kwong Kwok and Ishfaq Ahmad, ” Efficient Scheduling of Arbitrary Task Graphs to Multiprocessors Using a Parallel Genetic Algorithm, ” J. Parallel and Distributed Computing, Vol. 47, No. 1, pp.58-77, November 1997.
[17]J. H. Holland, Adaptation in Natural and Artificial Systems, Univ. of Michigan Press, Ann Arbor, 1975.
[18]Lee Wang, Howard Jay Siegel, Vwani P. Roychowdhury, and Anthony A. Maciejewski, “ Task Matching and Scheduling in Heterogeneous Computing Environments Using a Genetic-Algorithm-Based Approach, ” J. Parallel and Distributed Computing, Vol. 47, No. 1, pp.8-22, November 1997.
[19]Marco Di Natale and John A. Stankovic, “ Scheduling Distributed Real-Time Tasks with Minimum Jitter, ” IEEE Trans. on Computers, Vol. 49, No. 4, pp.303-316, April 2000.
[20]G. Rudolf, “ Convergence Properties of Canonical Genetic Algorithms, ” IEEE Trans. Neural Networks, Vol. 5, No. 1, pp. 96-101, January 1994.
[21]D. Janaki Ram, T. H. Sreenivas, and K. Ganapathy Subramaniam, “ Parallel Simulated Annealing Algorithms, ” J. Parallel and Distributed Computing, Vol. 37, No. 2, pp.207-212, September 1996.
[22]Hao Chen, Nicholas S. Flann, and Daniel W. Watson, “ Paeallel Genetic Simulated Annealing: a Massively Parallel SIMD Algorithm, ” IEEE Trans. Parallel and Distributed Systems, Vol. 9, No. 2, pp. 126-136, February 1998.
[23]Albert Y. Zomaya, Chris Ward, and Ben Macey, “ Genetic Scheduling for Parallel Processor Systems: Comparative Studies and Performance Issues, ” IEEE Trans. Parallel and Distributed Systems, Vol. 10, No. 8, pp.795-812, August 1999.
[24]Man Lin, Lars Karlsson, and Laurence Tianruo Yang, “ Heuristic Techniques: Scheduling Partially Ordered Tasks in a Multi-processor Environment with Tabu and Genetic Algorithm, ” Proc. of the 7th International Conference on Parallel and Distributed Systems, pp.515-523, July 2000.
[25]Samir W. Mahfoud and David E. Goldberg, “ Parallel recombinative simulated annealing: A genetic algorithm, ” Parallel computing, Vol. 21, No. 1, pp.1-28, January 1995.
[26]Feng-Tse Lin, Cheng-Yan Kao, and Ching-Chi Hsu, “ Applying Genetic Approach to Simulated Annealing in Solving Some NP-Hard Problems, ” IEEE Trans. on Systems, Man and Cybernetics, Vol. 23, No. 6, November/December 1993.
[27]A. H. Mantawy, Youssef L. Abdel-Magid, and Shokri Z. Selim, “ Integrating genetic algorithms, tabu search, and simulated annealing for the unit commitment problem, ” IEEE Trans. on Power Systems, Vol. 14, No. 3, August 1999.